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FINAL REPORT

"THE UNIVERSITY OF NEW HAMPSHIRE VACUUM CHAMBER

AND

CHARGED PARTICLE CALIBRATION SOURCE"

Supported under the Department of Defense-University Research Instrumentation Program Grant No. AFSOR-87-0018

Prin. .pal Investigator: Prof. Roger L. Arnoldy

INTRODUCTION

Grant # AFSOR-87-0018 provides partial support for the purchase and fabrication of a vacuum chamber facility to be used in the calibration of electron and ion detectors. The detectors are space flight instruments that will be flown aboard sounding rockets and shuttle missions to study two distinct problems of interest to DOD: 1) the physics of charged particle beam emission in the upper ionosphere (i.e., payload neutralization and beam stability); and, 2) the dumping of trapped radiation by low frequency radio transmitters and lightning strokes. Specific instrumentation requested includes a half cubic metor vacuum tank, stable ion source, He leak detector, system accessories and hardware to fabricate a positioning table. The University of New Hampshire will provide the cyrogenic vacuum pump and the technical personnel to fabricate the system. The University of New Hampshire has a great deal of experience in the plasma physics associated with the emission of electron and ion beams from sounding rockets in the upper ionosphere having participated in the design and instrumentation of nine such flights. Future work in this area involves the measurement of the ion and electron distribution functions in the region surrounding a particle beam emitting payload in order to understand the physics of payload neutralization. These measurements use pitch angle imaging detectors which we have built and successfully flown but require a calibration facility having a volume and particle beam control far in excess of present equipment. Finally, the radiation belt dumping experiment and the tracking of particle beams in the magnetosphere require the use of large detector systems which do not physically fit in our present calibration facility.

GENERAL DESCRIPTION

There are several major components to the vacuum chamber/charged particle calibration facility which has been funded under AFSOR-87-0018. The chamber itself has a volume of roughly one half a cubic meter. A mechanical drawing of the chamber is given in MC 2243. Under contract from the University of New Hampshire it was fabricated by Sharon Vacuum of Brockton, Ma. The cryogenic vacuum system was manufactured by Varian Associates and was provided to the project by the University of New Hampshire. The vacuum station can be operated manually or automatically by a DOT microcomputer. This will be more fully described in the next section. There are three components to the particle calibration portion of the facility, the electron gun, the ion source, and a positioning table which can move a detector along three rectilinear coordinates and rotate about three orthogonal axes in front of a particle beam.

The electron gun utilizes the technique described in a final report to AFSOR from Air Force Geophysics Laboratory for Contract # F49620-82-0035. The gun consists of gold coated quartz window which can be back illuminated with ultraviolet light of sufficient energy to produce photoelectrons in the gold coating. The photoelectrons are accelerated by a selected negative high voltage applied to the gold layer. The beam intensity is controlled by polarizing films placed between the ultraviolet source and the quartz window. One polaroid film is used as a polarizer and the rotation of a second analyzer film regulates the intensity of the UV light and consequently the electron beam intensity. A schematic of the electron gun is given in Figure 1.

The ion source uses the electron gun run at low voltage as a source of electrons to ionized atoms which are then accelerated by the high voltage of the source to create the ion beam. A schematic of the ion source is given in Figure 2. The ion source is fabricated but has not been extensively tested to determine its characteristics as of the present time.

The positioning table is being built in the University of New Hampshire Space Science Center machine shop. It is nearing completion. The translational and rotational motions will be provided by stepping motors operated by a microcomputer programmed to provide the desired scans. Eastern Air Devices of Dover, N.H. furnished the stepping motors to the University of New Hampshire free of charge for this project.

DETAILED DESCRIPTION OF THE VACUUM CHAMBER

I. PURPOSE

The cryopumped vacuum system has been designed to be an extremely clean vacuum system with quick turnaround times. The intended application is for testing and calibrating space flight instruments (that need such cleanliness) and, possibly, for conducting plasma experiments.

The heart of the cleanliness is the inherent cleanliness of the cryopump, combined with the filtering effects of the molecular sieve traps. These traps are installed to prevent oil backstreaming from the rotary van pump to the chamber or the cryopump body. Backstreaming occurs at pressures below ∿200 microns.

A. Specifications

COMPONENTS

Mechanical pump:	Vaian SD-700, 30cfm
Cryo pump:	Varian VK12-A, 8 inch
Cooler:	Neslab CFT-75, 2100 Watts
Vacuum gauge controller:	Granville-Phillips, 307 Series

PERFORMANCE

Ultimate pressure:	∿2E-7 Torr
Pumpdown speed (empty, clean chamber):	
	1.2E-6 T, 1 hour from crossover
	8.1E-7 T, 2 hours from crossover
	6.1E-7 T, 3 hours from crossover
Roughing speed:	10 minutes to 150 mT
	11 minutes to 100 mT
	12 minutes to 80 mT

UTILITIES

Electrical:	120 Volts, 30 Amps
	240 Volts, 20 Amps
Nitrogen:	Less than 1 PSI
Air:	80 PSI

B. System Drawings

MB 2347: General plumbing and electrical schematic
MB 2348: System hardware configuration

II. OPERATION

A. Front Panel Nomenclature and Function

All normal operations can be controlled via the front panel. The panel gives access to all 7 valves, the rotary vane (roughing) pump, the helium compressor and the compressor cooler. Functions of the various controls are as follows:

A. The "POWER" switch can not be disabled. When power is first turned on, all valves are shut and everything else is set to "OFF". This is done so that a recovery from a power failure will not power up into a strange state. Any time a power failure (or compressed air failure) occurs all valves will automatically shut and remain shut when power is returned.

B. All switches besides the power switch can be disabled by placing the "PANEL DISABLE" switch in the down position. This is done in order to prevent inadvertent operations.

C. The "PRESSURE DEFFERENTIAL" indicator lamp will signify a possible difference in pressure between the chamber and the cryo pump body. When this lamp is lit, valve V1 cannot be opened. This is done so that the valve cannot be opened while being forced against either the chamber or the pump body.

D. All swithches on this panel operate latching relays inside the controller. These relays can also be operated externally (by a DOT computer, for example) via the logic board inside the controller.

There are also separate switches on the helium compressor and the cooler. Both of these switches should be left on since the power to these units is controlled by relays inside the controller.

B. Valves, Traps and Plumbing Manifold

Refer to drawing MB2347.

Valves

There are seven valves used to control pumping. Valves V4/V5 and V2/V3 are sets of valves used to isolate the sieve traps so that the traps can be left under vacuum at all times. If not under under vacuum, these traps would accumulate moisture from the air and/or oil from the roughing pump. They should <u>always</u> be kept under vacuum. Valves V6 and V7 are Back-to-air-valves, one for the cryo pump body and one for the chamber. Valve V1 is the main valve, connecting the cryo pump to the chamber. It is a 6 inch swing gate valve. All valves are electro-pneumatic and will close if either the power or air supply fails. Valve V1 is the only valve that needs aire to close, but a backup air tank with a check valve is installed to serve that purpose.

There is also a small valve installed in the roughing hose. The purpose of this valve is to vent the roughing hose whenever the rough pump is turned off. If this was not done, oil would tend to backstream into the hose whenever the pump was shut off since the hose would still be under relatively high vacuum. This valve is a normally opened valve, connected to the same power line as the rough pump. As a result, whenever the rough pump is turned off, a hissing sould will be heard. This is normal.

Traps

There are two molecular sieve traps in the system. The purpose of these traps is to prevent oil from backstreaming into the chamber and/or the cryo pump body. Once these traps are charged with sieve material they should be baked out and pumped on. This procedure cleans the traps and, once clean, the traps should always be kept under vacuum. If removed, attention must be paid so that the traps are reinstalled in the correct orientation.

Plumbing Manifold

Refer to drawing MB2347.

C. System Monitors

There are several monitors in the system that are important

A. The first, viewed from the left side of the chamber, is a set of two gauges, mounted on the helium compressor. Together, these gauges indicate the helium pressure and differential pressure across the helium lines. The compressor should not be started (and will probably lockout) if the higher pressure is not 190 + 0/5 psi and/or the differential exceeds 3 psi.

B. Another important gauge is the temperature gauge of the cold head on the cryopump. This gauge is not readily accessible but can serve as a second check on the cold head temperature. The first check would come from the vacuum system controller or the DOT computer. A temperture diode is installed in the cold head with a power supply and monitor board installed in the controller. The temperature can be monitored using the DOT or the appropriate lookup table. Normal operating range is $\sim$12 to 16 degrees Kelvin.

C. Finally, a water pressure gauge is installed in the cooling unit. The cooling units' priority is a constant flow rate (at 1 GPM), with a maximum pressure of 60 psi. Under normal operating conditions, the pressure is $\sim$25 psi. If the pressure rises significantly, the reason may be a clogged or partially clogged water filter, installed externally.

D. Also, there is a thermistor epoxied to the water return line in the helium compressor. Its purpose is to double check the cooling system in order to help avoid any over heating (there is a thermal cutout in the helium compressor if all else fails). The thermistor is controlled by the monitor board in the controller, read and display by the DOT. Normal temperature is ∿25 degrees C. If a significant rise occurs, it may be due to the system being too close to a wall; some room is needed for air flow.

D. Manual Operation

There are two steps necessary to accomplish normal pumpdown. The first step is to pre-chill the cryopump body. This consists of rough pumping the sryopump and turning on the helium compressor to cool the cold head to a temperature of ∿14 degrees Kelvin. The second step, which can actually be overlapped with the first, is to rough pump the chamber. These two steps are independent of each other. Once roughed, the chamber can be "crossed over" to the cryopump (assuming it is cold). Before crossing over, the rough pump can be valved off and turned off-it is no longer needed. In more detail, the steps are as follows:

Pre-chill

1. Shut V1, V2, V3, V4, V5, V7.
2. Turn rough pump on.
3. Open V3 then V2. Sequence is important in keeping the traps under vacuum.
4. CAUTION: EXCESSIVE ROUGHING CAN SATURATE THE SIEVE TRAPS WITH OIL FROM THE ROTARY PUMP.

Rough the cryopump body to ∿10 mT, shut V2 then V3; monitor the pressure rise in the cryopump body (thermocouple gauge should have turned on with controller power). If the pressure rises faster than ∿1 mT/second then continue roughing for at least ten minutes and recheck pressure rise. The pressure rise is a result of the cryopump outgassing and is a sign that the cryopump needs to regenerated; regenerating this system usually simply consists of extending the roughing time.

5. Once the cryopump outgassing is insignificant and the body is roughed out, make sure V2 and V3 are both shut and turn the rotary pump off. Check the helium pressure gauges on the front of the helium compressor. The gauges should read 190+ 0/-5 psi. Turn the cooler on, then turn the helium compressor on. Again, order is important. The pump cold head temperature can be monitored using the DOT or by viewing the gauge at the very bottom of the cryopump. The pump is not ready for crossover until the temperature has reached ∿15 degrees Kelvin. Time required is approximately 1.5 hours.

Pumpdown

1. Prechill cryopump as descrived above.
2. Shut ALL valves.
3. Turn rough pump on.
4. Open V5 then V4; order is important

5. Rough pump chamber to 100 mT.
6. Shut V4 then V5, turn rough pump off. Hissing noise is normal. It is the roughing line vent valve that opens to prevent oil backstreaming and subsequently coating the roughing hose with oil.
7. Open V1. As the pressure drops, the ion gauge should turn on automatically.

Back-to-air (Chamber)

1. Turn off high voltage to prevent arcing.
2. Shut V4, V5 and V1.
3. Turn off ion gauge.
4. Open valve on nitrogen tank to supply dry nitrogen to chamber and purge vent line.
5. Shut the manual vent valve, located on back of chamber, mounted to the electro-pneumatic valve.
6. Open V6.
7. Allow nitrogen to flow briefly (~5 seconds) into chamber, then open manual vent valve and shut valve on nitrogen cylinder.

Back-to-air (Cryopump body)

NOTE: Under normal operation, there is no need to vent the pump back up to atmospheric pressure. Instead, simply shut V2, V3 and V1 and turn the compressor and the cooler off. The pressure inside the pump body will stabilize at some point that depends on how much pumping has been accomplished since the last regeneration. If, however, the pump body does need to be brought up to atmosphere (for maintenance or whatever), follow these steps:

1. Shut V2, V3 and V1
2. Open valve on nitrogen tank to supply dry nitrogen to pump body.
3. Open V7
4. Vent the pump body to atmospheric pressure. There is a relief valve on the bottom of the pump that will not allow pressurization above 1 or 2 psi above atm.

E. Computer Operation

Routine pumpdowns and regeneration can be accomplished using a DOT computer. The computer is interfaced to the controller via a 37 pin connector that conects to a logic board inside the controller. The controller is also interfaced to the vacuum system monitors and pressure gauges and passes some of that information on to the DOT. In this way, all processes and conditions can be monitored and recorded by the DOT.

Each of the routines on the DOT accomplishes the same abjectives as described under MANUAL OPERATION, above. A brief description follows:

Routine:	Function
chill:	Same as Pre-chill paragraph
vac:	Same as Pumpdown paragraph
air:	Same as Back-to-air (Chamber) paragraph
vacmon:	Monitors and displays system status.

E. Molecular Sieve Trap Regeneration

As the sieve traps become saturated, the rough pumping speed and ultimate pressure will decrease dramatically. When the roughing time for the chamber begins to approach fifteen minutes or more, it is time to regenerate the sieve traps.

III. INSPECTION AND MAINTENANCE

A. General

Routine inspection and maintenance procedures for the various assembled compenents are described in the appropriate sections towards the back of this manual and are briefly summarized below. Maintenance related to the miscellaneous subsystems is described below.

Maintenance to be performed every 1000 hours, as recorded by the compressor:

1. Inspect and clean inlet water orifice on helium compressor.
2. Inspect and/or replace filter on cooling water return line.
3. Inspect and clean strainer inside water cooler unit.
4. Check and fill oil level in air line lubricator.
5. Check oil level and oil condition in rotary van pump.
6. Check oil mist trap for clogging.

Maintenance to be performed every 6000 hours, as recorded by the compressor:

1. Replace absorber in helium hoses. Cryopump Manual

Maintenance to be performed every 15000 hours, as recorded by the compressor:

1. Replace expander seals, backup o-rings and valve disc in cryopump.
2. Replace self sealing fittings in helium hoses. Manual

As required:

1. Regenerate molecular sieve traps.
2. Regenerate cryopump.
3. Thermocouple gauge calibration.

B. Troubleshooting

This section refers to general system problems only. Troubleshooting for particular components can be found under the appropriate section in the back of this manual.

SYMPTOM:	POSSIBLE CAUSE:
Cannot rough pump chamber to expected pressure.	1. Sieve trap is saturated, needs to be regenerated. 2. Chamber has a leak. 3. Thermocouple gauge is out of calibration.

Cryopump temperature unusually warm (> 18 degrees Kelvin).	1. Pump needs to be regenerated. 2. Furhter troubleshooting steps in cryopump manual.
Front panel inoperative	1. PANEL ENABLE switch turned off (down). 2. Fuse blown inside controller.

IV. BIBLIOGRAPHY

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ELECTRON GUN

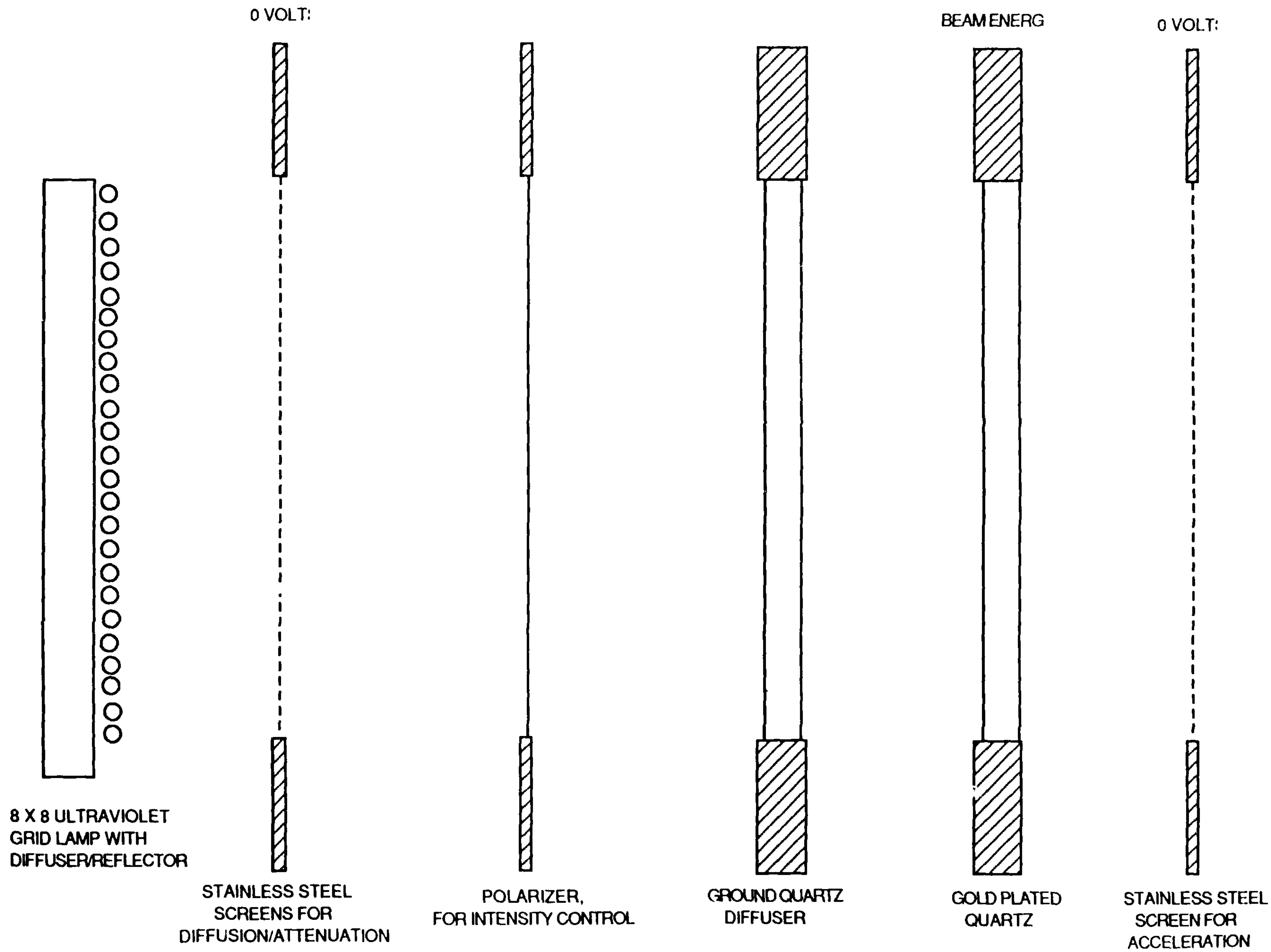

Figure 1

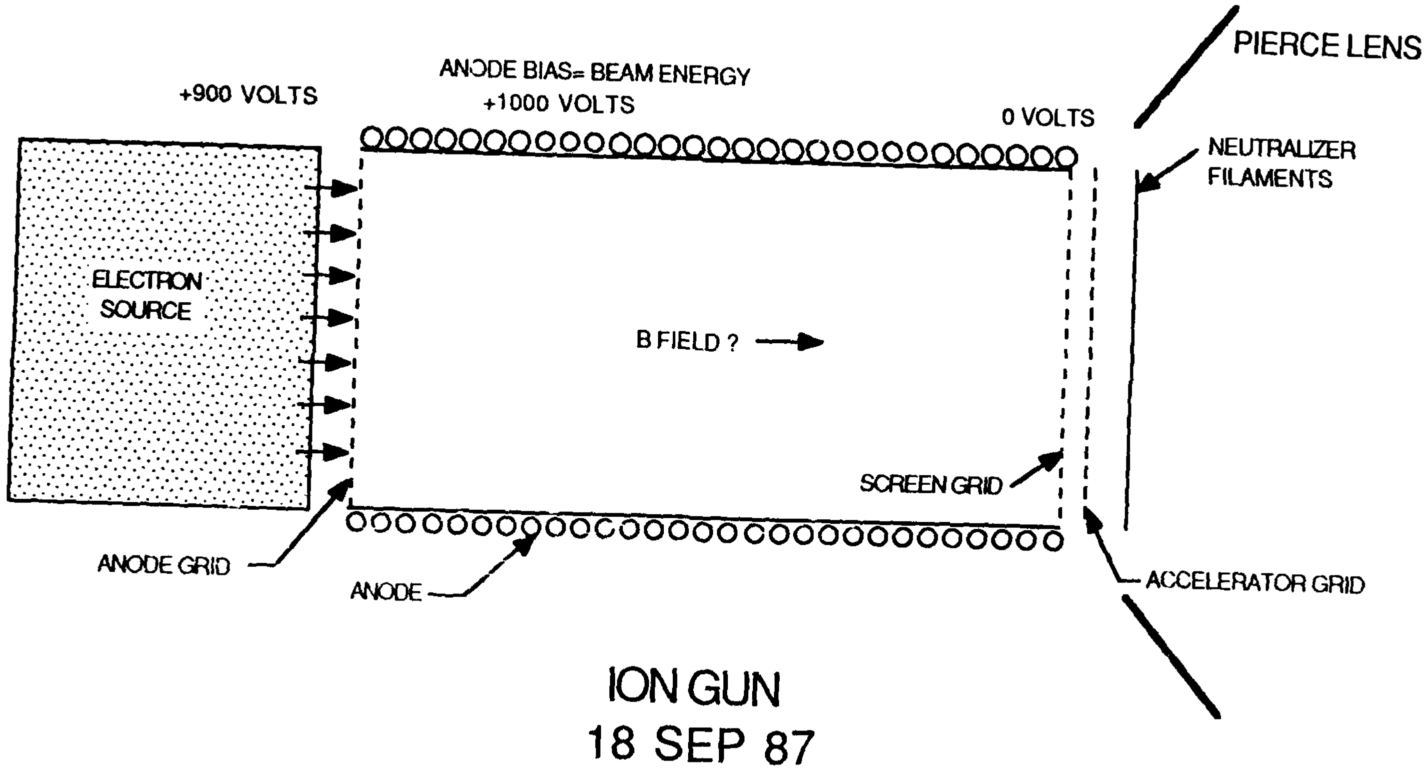
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Figure 2